CERES Validation Plan Summary

Bruce A. Wielicki
Bruce R. Barkstrom

Atmospheric Sciences Division
NASA Langley Research Center
Hampton, VA 23681-0001

Introduction

The CERES Validation Plans are currently being developed. Following a peer review in late 1996, the Validation Plans will be made available on the WWW in the Spring of 1997. In the interim, this separate document containing the Validation Plan Summary Charts for each major subsystem has been developed to accompany the ATBDs. This CERES Validation Plan Summary provides the basic elements of each plan in a common format for all the subsystems. This includes a concise overview of the data to be validated, the validation techniques and approach to be applied, and data sources to be used for validation.

The Validation Plan Overview charts provide a top-level roadmap for our approach to validation. These charts summarize the major types of data to be validated, validation data sets, techniques, and approaches, and an estimate of the relative usefulness of the different techniques and data sets for application in validating the major types of data. In addition, 1-page summary charts are presented for each individual subsystem for use by ATBD reviewers. Each summary chart gives the primary point of contact for that subsystem and the specific data products, approaches, and validation activities for each phase of the mission. All of the validation summaries apply to the TRMM, EOS AM-1, and EOS PM-1 missions.

CERES Validation Plan Overview

- **Five major data types to validate:**
  1) Instrument broadband radiances
  2) Top of atmosphere radiative fluxes
  3) Surface radiative fluxes
  4) Atmosphere radiative fluxes
  5) Cloud properties

- **Seven major validation techniques**

  1) Onboard calibration *(pre- and post-launch calib.)*
  2) Theoretical sensitivity studies *(radiative modeling)*
  3) Pre-launch satellite data surrogates *(ERBE/AVHRR/HIRS)*
  4) Internal consistency checks *(e.g. view zenith dependence)*
  5) Surface Sites
     - Current surface sites *(ARM, BSRN, SURFRAD, GEBA)*
     - EOS-enhanced surface sites *(add MFRSR, lidar, radar, etc.)*
  6) Other Satellite Data (MISR, ASTER, GLAS, ESSP)
  7) Field Campaigns (e.g., FIRE, SHEBA, INDOEX)

Data Product / Validation Strategy Matrix

(1 = Critical; 2 = Important; 3 = Useful)

Validation Technique	Radiance	TOA	SFC	Atmosphere	Cloud
Onboard calibration	1	1	1	1	1
Theoretical sensitivity studies	2	3	3	2	2
Pre-launch satellite data surrogate	2	2	2	3	2
Internal consistency check	2	1	3	2	2
Surface Sites					
- Current surface sites			1	1	1
- EOS-enhanced surface sites			1	1	1
Other EOS-era Satellite Data	3	2	1	1	1
Field Campaigns			2	2	2

Instrument Radiance Calibration/Navigation Validation

- **Products:** Broadband shortwave, total, and window radiances
(0.3 - 5µm, 0.3- >100µm, 8 - 12µm)

- **Prioritized Validation Approaches:**
  1) Consistency of pre-launch and post-launch calibration: on-board, calibration chamber (Blackbodies, Lamp/photo-diode, Mirror Attenuator Mosaic, Space Scan)
  2) Comparison of multiple CERES instruments in orbit
  3) Consistency with ERBE statistics (e.g. 30S-30N ocean nadir radiance)
  4) 3-channel consistency checks
  5) Navigation consistency check against cloud imager and coastlines

TOA Radiative Fluxes Validation

- **Products:** Shortwave and Longwave Top of Atmosphere Fluxes

- **Prioritized Validation Approaches:**
  1) Develop new broadband angular models using CERES Rotating scanner
  2) Compare pixel flux inversion to Sorting into Angular Bins for monthly mean
  3) Viewing zenith angle dependence of TOA albedo and LW flux
  4) Multiple CERES scanner angle of view instantaneous intercomparisons
     - along track observations
     - crosstrack and rotating azimuth scanner observations
     - multiple satellite coincidences
  5) Consistency with narrowband MISR and POLDER anisotropy

Surface Radiative Fluxes Validation

- **Products:** Shortwave and Longwave Surface Radiative Fluxes

- **Prioritized Validation Approaches:**
    1) Class 1 ARM sites (3): Oklahoma, Tropical Pacific, North Slope (i.e., CERES/ARM/GEWEX: CAGEX)
    2) Class 2 Climate Trend Sites (~10): Modified BSRN, SURFRAD, etc.
    3) Class 3 Discrete Validation Sites (>100): BSRN, ISIS, GEBA
    4) Satellite based cloud lidar/radar for cloud overlap and cloud base globally
    5) MISR/MODIS/ASTER/CERES to subtract atmosphere at class 1, 2 sites
    6) Theoretical modeling of 1-D, 2-D, and 3-D radiative effects on SFC fluxes
    7) Field campaigns (FIRE, SHEBA, INDOEX, etc.)

Atmospheric Radiative Fluxes Validation

- **Products:** Shortwave and Longwave Atmosphere Radiative Fluxes

- **Prioritized Validation Approaches:**
    1) Aircraft flights at Class 1 and Class 2 sites
    2) Aircraft flights during field experiments
    3) Remotely sensed 2-D vertical profiles at Class 1 and Class 2 sites: atmosphere + cloud microphysics + radiative models
    4) Satellite based cloud lidar/radar for cloud overlap and cloud base globally
    5) Class 2 Climate Trend Sites (~10): Modified BSRN, SURFRAD, etc.

Cloud Properties Validation

- **Products:** Cloud fraction, temperature, height, optical depth, LWP/IWP particle phase/size, limited multi-layering information

- **Prioritized Validation Approaches:**

1) Cloud Fraction
   · Space based lidar
   · ASTER or Landsat to resolve “beam filling”: 40 cloud climatological targets
   · Surface based lidar at Class 1 and 2 sites: thin cloud detection: used in early validation work prior to availability of space-based lidar
   · Surface observer network

2) - Cloud Top/Base Height/Temperature/Pressure, Overlap Condition
   · Space-based lidar + radar (lidar: optically thin limit; radar: optically thick limit)
   · Class 1 and Class 2 surface site lidar/radar data
   · Internal consistency: multiple algorithms, viewing zenith angle dependence
   · Field experiment lidar/radar data (few cases, however)
   · Routine surface observations (ceilometer to 4km, multi-layer cloud type)
   · Theoretical sensitivity analysis

3) - Cloud Optical Depth, Particle Phase/Size, LWP, IWP
   · Class 1 and Class 2 Surface Sites with microphysical profiling (lidar + radar + passive microwave + 11 µm radiometer)
   · Comparison to passive microwave LWP retrievals at moderate to large LWP.
   · New satellite microwave remote sensing for IWP and ice particle size.
   · Internal consistency: multiple satellites, viewing zenith angle dependence
   · Theoretical sensitivity analysis: 1-D, 2-D, and 3-D radiative modeling

CERES VALIDATION SUMMARY

Subsystem 1.0 - CERES Geolocate and Calibrate Earth Radiances

Robert B. Lee III, NASA Langley Research Center

Data Products

- Earth radiances:
  1) Filtered broadband shortwave [0.3 - 5.0 μm]
  2) Total-wave [0.3 - >100 μm]
  3) Water vapor window [8 - 12 μm]

Approach

- Resolution/geometric sites used during the ERBE spacecraft missions
- Radiometric accuracy and precision in-flight calibration systems [demonstrated by ERBE] measurement accuracy via ground-to-orbit and precision via in-flight time series
- Radiometric precision/consistency checks among same and different types of CERES sensors using ERBE techniques
- Compare CERES radiances to earth validation targets calibrated with 5 years of ERBS data
- Three channel redundancy check for consistency
- Offsets validated using spacecraft pitch-up and monitored monthly against ERBS global limb-darkening

Validation Activities

- Prelaunch
  1) All validation and consistency checks will be based upon CERES sensor ground calibration data sets.
  2) Establish radiation statistics of earth validation targets. Longwave target is tropical ocean at night. Shortwave target is desert region in daytime. Learn technique by applying to ERBE NOAA-9 data.
- Postlaunch
  1) Collect in-flight calibration measurements and calculated filtered Earth radiances on designated calibration days.
  2) Compare CERES radiances to historical ERBS radiances via earth validation targets.

Archive

- In-flight calibrations will be archived in BDS format at EOSDIS.
- Publications describing the sensor calibration and validation results as well as public science computing facility (SCF) files of the appropriate calibration and validation data.

CERES VALIDATION SUMMARY

Subsystem 2.0 - ERBE-like Inversion to Instantaneous TOA Fluxes

Richard N. Green, NASA Langley Research Center

Data Products and Parameters

- Parameters: ERBE-like ADMs, ERBE-like TOA flux
- Product: CERES ES-8

Approach

- Test ADMs with SAB Method (SAB monthly means independent of ADMs)
- Build new ADMs from CERES data
- Constant Flux Test (flux consistency with viewing zenith)
- Compare ERBE-like flux with CERES flux (same data, different scene ID and ADMs)
- Intercompare ERBE-like flux from TRMM and EOS AM-1

Validation Activities

- Prelaunch
    1) Test ADMs with SAB Method using Nimbus-7 data
    2) Apply Constant Flux Test to ERBE along-track data
    3) Validate data processing system using CERES simulation
    4) Establish mean and variance of difference between ERBE-like flux and CERES flux from CERES simulation
- Postlaunch
    1) Test ADMs with SAB Method using CERES RAP data
    2) Build new ERBE-like ADMs from CERES data and compare with current ADMs
    3) Apply Constant Flux Test with CERES data
    4) Determine flux difference between ERBE-like flux and CERES flux and test against prelaunch statistics

Archive

- All validation tests are off-line.

CERES VALIDATION SUMMARY

Subsystem 3.0 - ERBE-Like Averaging to Monthly TOA Fluxes

David F. Young, NASA Langley Research Center

Data Products

- ERBE-like clear-sky and all-sky radiative parameters at the TOA on various spatial (regional, zonal, and global) and temporal (daily, monthly-hourly, and monthly mean) scales

Approach

- Pre-launch science studies for improving and verifying TISA methods
- Compare ERBE-like results with validation data sets
- Intercompare ERBE-like results from TRMM and EOS satellites

Validation Activities

- Prelaunch
    1) Complete validation of the ERBE-like science algorithm
    2) Finish testing of the ERBE-like data processing system
    3) Verify ERBE-like TOA results with existing ERBE scanner data
    4) Validate data processing system using CERES end-to-end simulation
- Postlaunch
    1) Primary comparison with geostationary data using narrowband-to-broadband conversion technique
    2) Secondary direct verification (if available) with ERBE WFOV results, ScaRaB data, and GERB data
    3) Additional intercomparison between TRMM, EOS AM-1, and EOS PM-1 data
    4) Continuous monitoring of the quality of the input data product and detecting problems in the overall system

Archive

- EOSDIS: Special processing of CERES ERBE-like data products containing validation sites.

CERES VALIDATION SUMMARY

Subsystem 4.1 - Imager Clear-sky Determination and Cloud Detection

Bryan A. Baum, NASA Langley Research Center

Data Products

- Parameters: Cloud mask and clear-sky surface classification
- Product: CERES SSF

Approach

- Complete pre-launch science studies for detection of clouds in imager data
- Compare results with surface observations
- Intercompare results with other satellites

Validation Activities

- Prelaunch
    1) Global analyses using AVHRR LAC and GAC data and regional analyses using MAS data
    2) Compare imager-based retrievals with visual surface observations, lidar and radar time series, and all sky camera data from field experiments (e.g., ARM, FIRE, ECLIPS, ASTEX)
- Postlaunch
    1) Intercompare of ASTER and MODIS cloud mask retrievals
    2) Intercompare MODIS on EOS-AM with AVNIR on ADEOS
    3) Compare satellite-based cloud mask retrievals with NCEP surface station reports
    4) Compare imager-based retrievals with data from field experiments (e.g., ARM, FIRE, ECLIPS, ASTEX)

Archive

- EOSDIS: Special high-resolution cloud imager analyses over validation regions
- Documentation of validation results

CERES VALIDATION SUMMARY

Subsystem 4.2 - Imager Cloud-Layer and Cloud-Height Determination

Bryan A. Baum, NASA Langley Research Center

Data Products

- Parameters: Cloud-top and cloud-base heights for both single- and multiple-layered clouds
- Product: CERES SSF

Approach

- Develop global and regional maps of retrieved cloud heights
- Verify that global and regional analyses indicate consistent results moving from ocean to land, day to night, snow to water, desert to water, etc.
- Compare retrieved cloud boundaries with ground-based, other satellite-based, or aircraft-based data of cloud boundaries (most appropriate for stratiform clouds)
- Compare simultaneous retrievals from multiple satellites, aircraft and satellite, or surface and satellite

Validation Activities

- Prelaunch
  1) Cloud height: Compare satellite retrievals with cloud boundary data from field programs (lidar, radar)
  2) Cloud layers: Compare surface synoptic observations with satellite retrievals of single and multilevel cloud occurrences
- Postlaunch
  1) Increase number of long-term surface monitoring sites to include multilatitude oceans, mountains, deserts, and tropical land
  2) Develop field programs over surface types where little if any data currently exist, such as deserts
  3) Perform quick-look global and regional analyses of cloud boundary products
  4) Compare imager-based cloud boundary retrievals with validation site observations

Archive

- EOSDIS: Perform subsetting of processed full-resolution CERES imager data stream
- Archive validation site cloud boundary data

CERES VALIDATION SUMMARY

Subsystem 4.3 - Cloud Optical Property Retrieval

Patrick Minnis, NASA Langley Research Center

Data Products

- Cloud Phase, Effective Particle Size, Water Path, Optical Depth, Emittance, Radiating Temperature, and Thickness

Approach

- Compare in-situ and surface/aircraft remote sensing results to yield estimates of bias errors
- Analyze simultaneous retrievals from multiple satellites or aircraft and satellite to produce statistics, relative errors, and scene/angle dependence
- Perform model calculations to determine algorithm sensitivities to input and assumptions and improve physical understanding of observations

Validation Activities

- Prelaunch
    1) Complete analyses of field program data and compare with satellite retrievals
    2) Develop and analyze matched satellite data sets having appropriate spectral channels
    3) Study algorithm sensitivity to cloud inhomogeneities, viewing and illumination conditions, background, and input
    4) Identify key climate regimes needing further validation
- Postlaunch
    1) Increase number of long-term monitoring sites
    2) Develop field programs and instruments for long-term deployment
    3) Perform quick-look analyses of global products
    4) Combine full-resolution CERES and validation site data sets; perform comparisons
    5) Compare retrievals to those from other satellites and instruments

Archive

- EOSDIS: Archive combined CERES and correlative data sets

CERES VALIDATION SUMMARY

Subsystem 4.4 - Convolution of Imager Cloud Properties with CERES Footprint Point Spread Function

Richard N. Green, NASA Langley Research Center

Data Products

- Parameter: Point spread function (PSF) which sets location and size of CERES footprint and averaging weights
- Product: CERES SSF

Approach

- Regress CERES data on imager data and minimize variance with PSF centroid and dispersion.

Validation Activities

- Prelaunch
    1) Develop regression technique of locating the best fit of CERES and imager data and develop statistics of minimum variance point. Use ERBS and AVHRR data for pre-launch studies.
- Postlaunch
    1) Apply regression technique to first month of CERES data from TRMM and EOS-AM.

Archive

- All validation tests off-line.

CERES VALIDATION SUMMARY

Subsystem 4.5 - CERES Inversion to Instantaneous TOA Fluxes

Richard N. Green, NASA Langley Research Center

Data Products

- Parameters: TOA flux, CERES 200 ADMs
- Product: CERES SSF

Approach

- Test ADMs with SAB Method (monthly means, no ADMs)
- Along-track test (flux growth with viewing zenith)
- MISR comparison (compare to independent data)
- TOA flux bias and variance determined from ADM bias and variance

Validation Activities

- Prelaunch
    1) Validate ERBE12 ADMs for initial CERES inversion
- Postlaunch
    1) Validate CERES 200 ADMs
    2) Intercompare ERBE-like flux and CERES flux

Archive

- All validation tests off-line.

CERES VALIDATION SUMMARY

Subsystem 4.6 - Empirical Estimates of Shortwave and Longwave Surface Radiation Budget Involving CERES Measurements

David P. Kratz, NASA Langley Research Center

Data Products

- CERES SSF: Net shortwave surface flux; Clear-sky downward longwave ($\lambda > 5.0\ \mu m$), window ($8\ \mu m < \lambda < 12\ \mu m$) and non-window surface fluxes (Wm^{-2}); and Cloudy-sky downward and net longwave surface fluxes.

Approach

- Compile data base of simultaneously measured TOA and net surface SW and LW fluxes, atmospheric temperature, and total column water vapor.
- Apply radiative transfer algorithms to measured TOA data to derive surface fluxes.
- Compare simulated and measured surface radiation fluxes, apply an error analysis to the results, and evaluate against established criteria (rms errors of $\pm$ 20 Wm^{-2} for instantaneous retrievals; $\pm$ 10 Wm^{-2} for gridded monthly averages for both SW and LW.

Validation Activities

- Prelaunch: Compare algorithm results with measured data
  1) Tower Measurements (e.g., Boulder, Saskatoon, etc.)
  2) Data from the Global Energy Balance Archive (GEBA)
  3) Pyrgeometer measurements from research vessels in conjunction with brightness
  4) Temperature measurements by the Japanese Geostationary Meteorological Satellite
  5) ARM/CART measurements taken at the Southern Great Plains (SGP) site.
- Postlaunch: Compare CERES results with observations
  1) ARM/CART measurements taken at the Tropical Western Pacific (TWP) and the North Slope Alaska (NSA) sites.
  2) NOAA Integrated Surface Irradiance Study (ISIS), which utilizes surface fluxes measured by the NOAA Surface Radiation (SURFRAD) network in the U.S.
  3) World Climate Research Program (WCRP) Baseline Surface Radiation Network (BSRN) at selected sites around the globe.
  4) ARM/CART measurements taken at the Southern Great Plains (SGP) site.

Archive

- Validation data and results will be made available through anonymous ftp and/or through the World Wide Web.

CERES VALIDATION SUMMARY

Subsystem 5.0 - Compute Surface and Atmospheric Fluxes

Thomas P. Charlock, NASA Langley Research Center

Data Products

- Broadband SW and LW fluxes at surface, 500 hPa, tropopause, and TOA; photosynthetically active radiation at surface; adjustments to cloud, atmospheric, and surface properties that balance computed fluxes with TOA measurements

Approach

- Develop a long-term data base of surface radiation, aerosols, cloud lidar, cloud radar, and vertical flux profiles based on non-EOS surface measurements, helicopter surveys, and aircraft campaigns.
- Combine observations with CERES radiative transfer model to determine regional forcing of aerosols and surface. Compare model results with observations.

Validation Activities

- Prelaunch
    1) Validation of CERES global algorithm; compare model results with satellite data (i.e., GEWEX SRB) and surface data (i.e., GEBA)
    2) Expand current CAGEX from ARM CART SGP site for GCIP
    3) ARESE October 1995 study with aircraft fluxes and CAGEX to determine sampling pattern of post-launch flights
    4) Helicopter survey of surface optical properties at key sites; Whitlock spectral SW for MISR/MODIS/ASTER/CERES
- Postlaunch: Compare SARB results with surface-based measurements and other data
    1) CAGEX to cover all 3 ARM sites
    2) Aircraft fluxes (vertical profiles) and helicopter surveys of surface sites
    3) Determine climate forcing of aerosols, surface changes at Class 2 sites; extend regionally with satellite data
    4) Ship of opportunity with cloud lidar and pyrgeometer needed for cloud base height, surface LW flux (supplemented with surface measurements)

Archive

- EOSDIS: Special processing of CERES data from regions containing selected surface sites and for roving ship monitor; development of CAGEX-like data bases at selected sites.

CERES VALIDATION SUMMARY

Subsystem 6.0 - Grid Single Satellite Fluxes and Clouds and Compute Spatial Averages

G. Louis Smith, NASA Langley Research Center

Data Products

- Hourly single satellite flux and cloud parameters averaged over 1 regions (FSW Product)

Approach

- The gridded results are the regional averages of the measurements. The Release 2 algorithm for CERES is the Alley Oop algorithm which was used for ERBE, i.e. the average of the pixels whose centroid lies in the region. The Constrained Least Square (CLS) method is proposed for computation of the regional averages for data taken in the cross-track scan mode, and the Best Regional Integral Estimator (BRIE) is proposed for the computation of regional averages from the azimuthally rotating (biaxial) mode. Analyses will be made of the Alley Oop, CLS, and BRIE methods to define the errors of each method. Simulation studies will also be performed to provide examples of the problem. All validation work will be done prior to the first CERES instrument flight.

Validation Activities

- Prelaunch
    1) The spatial spectra of the output products, i.e. the outgoing longwave and reflected shortwave fluxes, can be developed from ERBE and AVHRR data for a wide range of spatial wavelengths. The gridding/averaging simulations will use geosynchronous satellite data at a scale which is small compared to the CERES pixel size.
    2) One result of the analyses will be a curve of regional averaging error as a function of view zenith angle to the center of the region for each algorithm. This curve will define the limits of the applicability of the algorithm.
    3) The CLS algorithm and BRIE algorithms will be implemented only if they are demonstrated to have a clear superiority in accuracy over the Alley Oop algorithm. Secondly, the limits of each algorithm will be defined.
- Post-launch
    1) No post-launch activity is planned.

Archive

- EOSDIS: Operational software will incorporate the results of the validation studies.
- Papers will be published describing the validation studies, in the open literature and in project documents.

CERES VALIDATION SUMMARY

Subsystem 7.0 - Time Interpolation and Synoptic Flux Computation for Single and Multiple Satellites

David F. Young, NASA Langley Research Center

Data Products

- TOA, in-the-atmosphere, and surface flux and clouds layer information in the atmosphere at 3-hourly GMT time resolution over the whole globe

Approach

- Complete prelaunch science studies for improving and verifying TISA methods
- Compare results with validation data sets
- Intercompare results from TRMM and EOS satellites

Validation Activities

- Prelaunch
  1) Complete validation of the science algorithm
  2) Verify TOA results with historical ERBE TOA scanner data
  3) Verify science algorithm using geostationary data, CAGEX, and TOGA data
  4) Validate data processing system using CERES end-to-end simulation
- Postlaunch
  1) Primary comparison of TOA fluxes with geostationary data using narrowband-to-broadband conversion technique
  2) Secondary direct verification of TOA fluxes (if available) with ERBE WFOV results, ScaRaB data, and GERB data
  3) Comparison with cloud and radiation data collected from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV)
  4) Comparison with cloud and radiation data collected from special validation regions; including class 1 and class 2 sites (i.e., Walker Tower, Boulder Tower, NOAA sites, and BSRN sites)
  5) Intercomparison between TRMM, EOS AM-1, and EOS PM-1 data

Archive

- EOSDIS: Special processing of CERES SYN data products containing validation sites.

CERES VALIDATION SUMMARY

Subsystem 8.0 - Monthly Regional, Zonal, and Global Radiation Fluxes and Cloud Properties

David F. Young, NASA Langley Research Center

Data Products

- Monthly mean and monthly-hourly mean radiative flux and cloud property information on regional, zonal, and global scales (from AVG and ZAVG data products).

Approach

- Complete science studies for improving and verifying TISA methods.
- Compare results with validation data set.

Validation Activities

- Prelaunch
  1) Complete validation of the science algorithm.
  2) Verify TOA results with historical ERBE TOA scanner data.
  3) Perform case study using CAGEX and TOGA data to verify science algorithm.
  4) Validate data processing using CERES end-to-end simulation.
- Postlaunch
  1) Compare TOA fluxes with geostationary data using narrowband-to-broadband conversion technique.
  2) Verify TOA fluxes with ERBE WFOV results, ScaRaB data, and GERB data.
  3) Compare with cloud and radiation data collected from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiments).
  4) Compare with cloud and radiation data collected for special validation regions including Walker Tower, Boulder Tower, NOAA sites, and BSRN sites
  5) Intercompare TRMM, EOS AM-1, and EOS PM-1 data.

Archive

- EOSDIS: Special processing of CERES AVG and ZAVG data products containing validation sites.

CERES VALIDATION PLAN

Subsystem 10.0 - Monthly Regional TOA and Surface Radiation Budget

David F. Young, NASA Langley Research Center

Data Products

- Monthly and monthly-hourly regional, zonal, and global averages of the TOA and surface LW and SW fluxes and the observed cloud conditions for each of the CERES region

Approach

- Complete pre-launch science studies for improving and verifying TISA methods
- Verify input/output operations and interface compatibility with other subsystems
- Compare results with validation data set

Validation Activities

- Prelaunch
    1) Complete validation of the science algorithm
    2) Verify TOA results with historical ERBE TOA scanner data
    3) Perform case study using CAGEX data to verify science algorithm
    4) Validate data processing system using CERES end-to-end simulation
- Postlaunch
    1) Compare TOA fluxes with geostationary data using narrowband-to-broadband conversion technique
    2) Verify TOA fluxes with ERBE WFOV results, ScaRaB data, and GERB data
    3) Compare with cloud and radiation data collected from intensive field experiments (i.e., TOGA, FIRE, CAGEX, ARM/TWP, ARM/NSA, and UAV experiments)
    4) Compare with cloud and radiation data collected for special validation regions including Walker Towers, Boulder Tower, NOAA sites, and BSRN sites
    5) Intercompare TRMM, EOS AM-1, and EOS PM-1 data

Archive

- EOSDIS: Special processing of CERES SRBAVG data products containing validation sites